Occurrence of Microcystin in Ozark Streams across a Nutrient Gradient in Northwest Arkansas

B.J. Austin, D.R. Lee, B.E. Haggard

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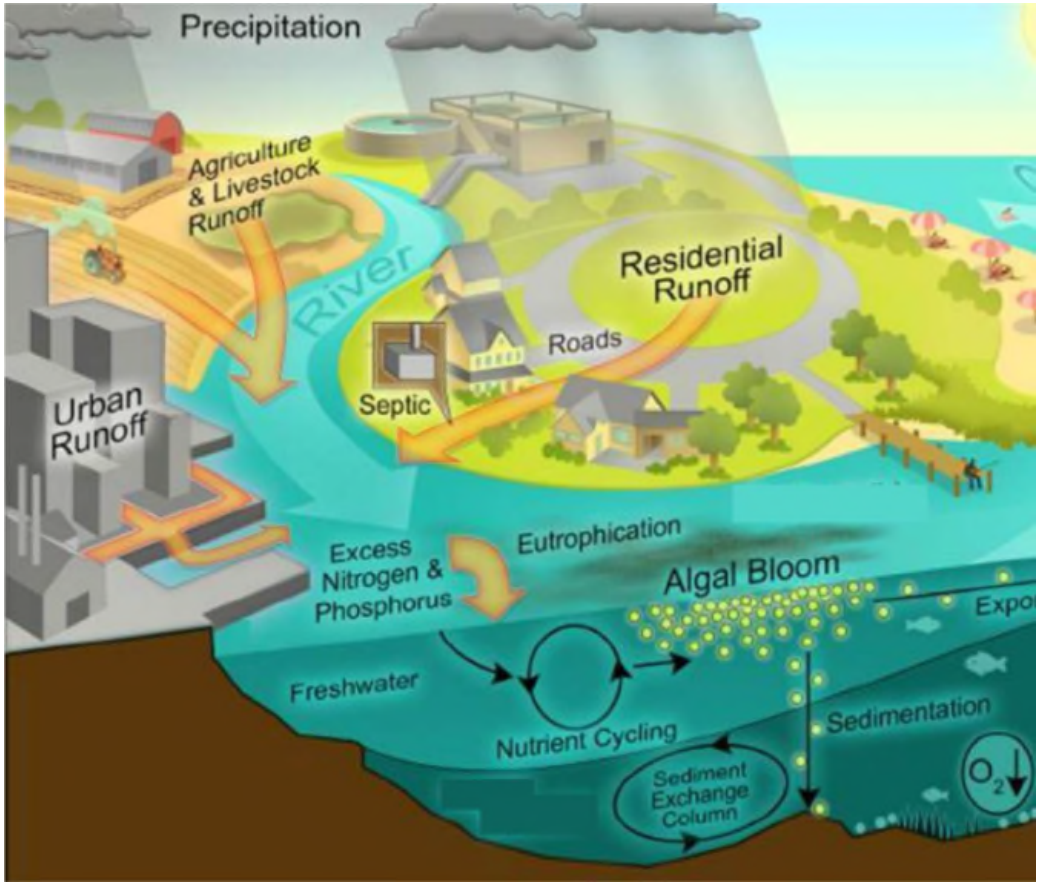
Eutrophication has likely contributed to the increased occurrence of harmful algal blooms



Modified from Paerl et al. (2006).

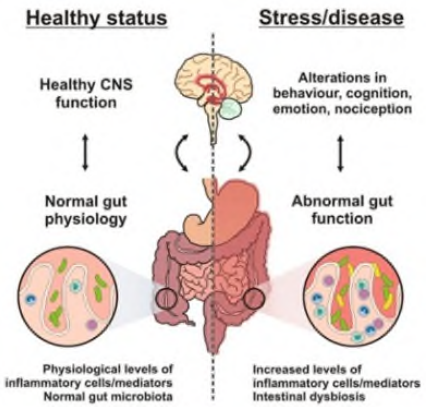
However, it's not just the concentration of N and P, the ratio is important too.

Other factors:

- Warming temperatures
- Slow moving water
- Light availability
- pH changes
- Alteration of water flow

HABs have been linked to:

- Health issues in people, pets, and wildlife
- Increased cost of treating drinking water
- Lost revenue due to
  - Wildlife mortality
  - Reduced tourism
  - Lake closures




Dead zone. From: EPA

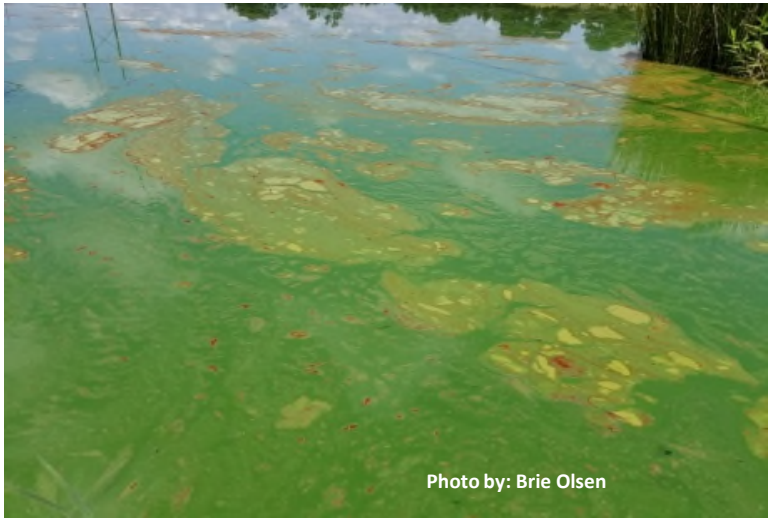


Photo by: Brie Olsen


Photo by: Melanie Treat

Much of what we know about freshwater cyanobacteria HABs center around ponds and lakes. But streams and rivers are important too.

- Experience similar environmental drivers.
  - Nutrient pollution
  - Warming temperatures
  - Low summer flow
- May inoculate downstream lakes with cyanobacteria.
- Many rivers serve as a drinking water source.
- Increased reports of animal deaths due to benthic-mat-forming cyanobacteria in streams

The goal of this study was to monitor Northwest Arkansas (NWA) streams for cyanobacteria using microcystin, and examine potential controlling factors.

Objectives:

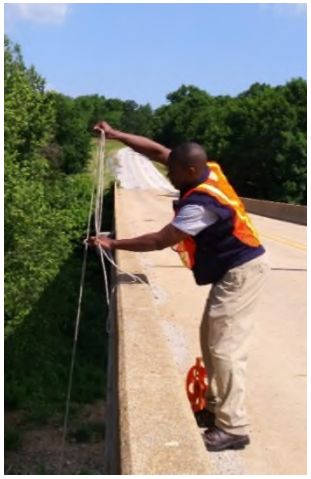
- Determine whether microcystin is present in NWA streams.
- Evaluate how microcystin relates to land use.
- Evaluate relationships between microcystin, nutrients and phytoplankton/periphyton biomass.

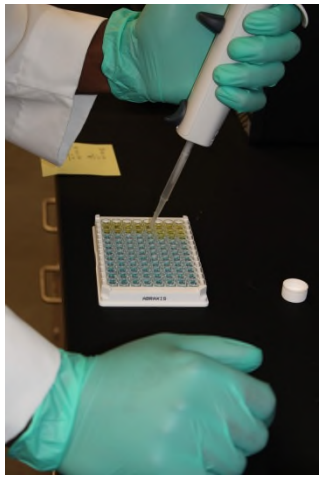
Experimental Design

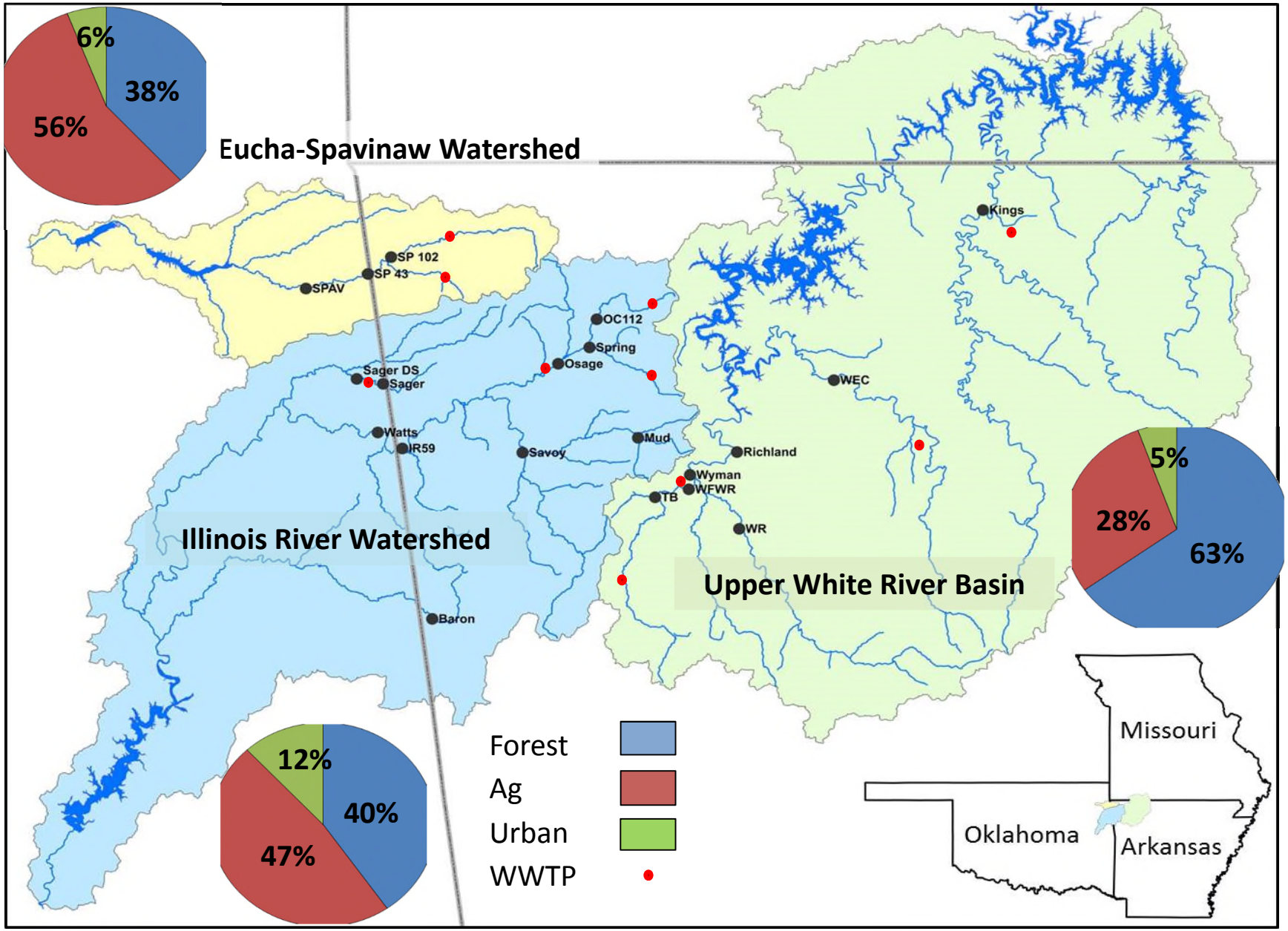
- Monitored water quality and microcystin in streams across a land use gradient.
  - 20 streams
  - Sampled bi-weekly May 25th through July
  - Monthly from August through October
- Sampled periphyton across the same land use gradient.
  - Bi-weekly in June and July
  - 1 riffle unit nearest the USGS station at each stream
  - 15 cobbles randomly selected across 3 transects
  - Scrubbed in the field and a composite sample was returned to the lab

Methods

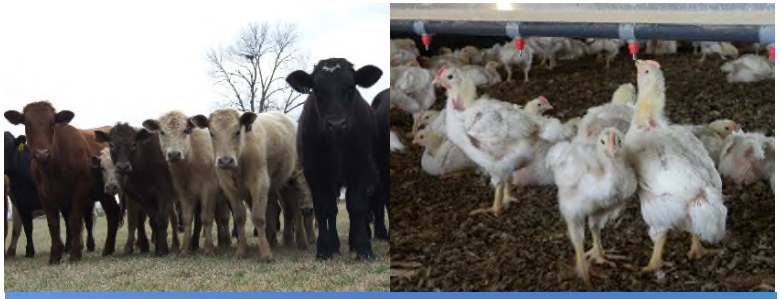
- Water samples were analyzed at the Arkansas Water Resources Center Certified Water Quality Lab.
- Periphyton was analyzed for chlorophyll-*a* (CHL-*a*) and ash free dry mass (AFDM)
- We used the Abraxis system to measure microcystin in water samples and periphyton slurries using the Microcystins-ADDA ELISA (Enzyme-Linked Immunosorbent Assay) Kit.



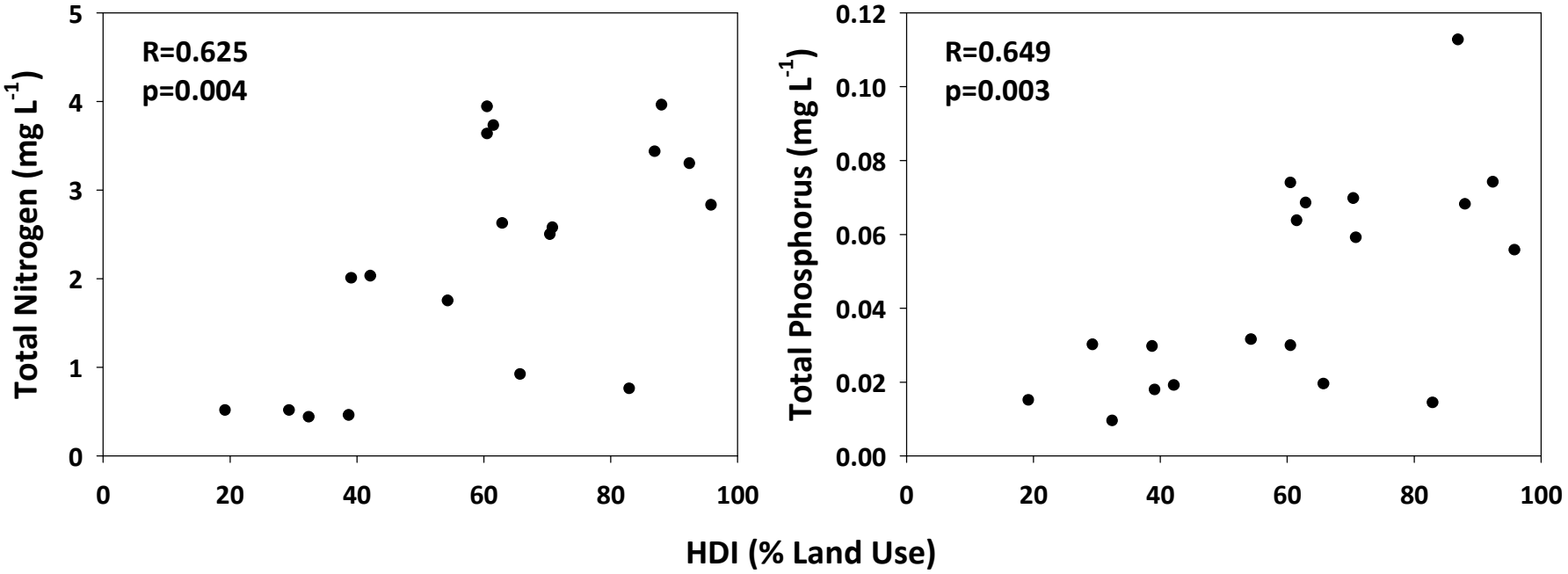



6%
38%
56%
Eucha-Spavinaw Watershed
SP 102
SP 43
SPAV
OC112
Spring
Osage
Sager DS
Sager
Watts
IR59
Savoy
Mud
Kings
WEC
Richland
Wyman
WFWR
TB
WR
Illinois River Watershed
Upper White River Basin
Baron
5%
28%
63%
12%
40%
47%
Forest
Ag
Urban
WWTP
Missouri
Oklahoma
Arkansas

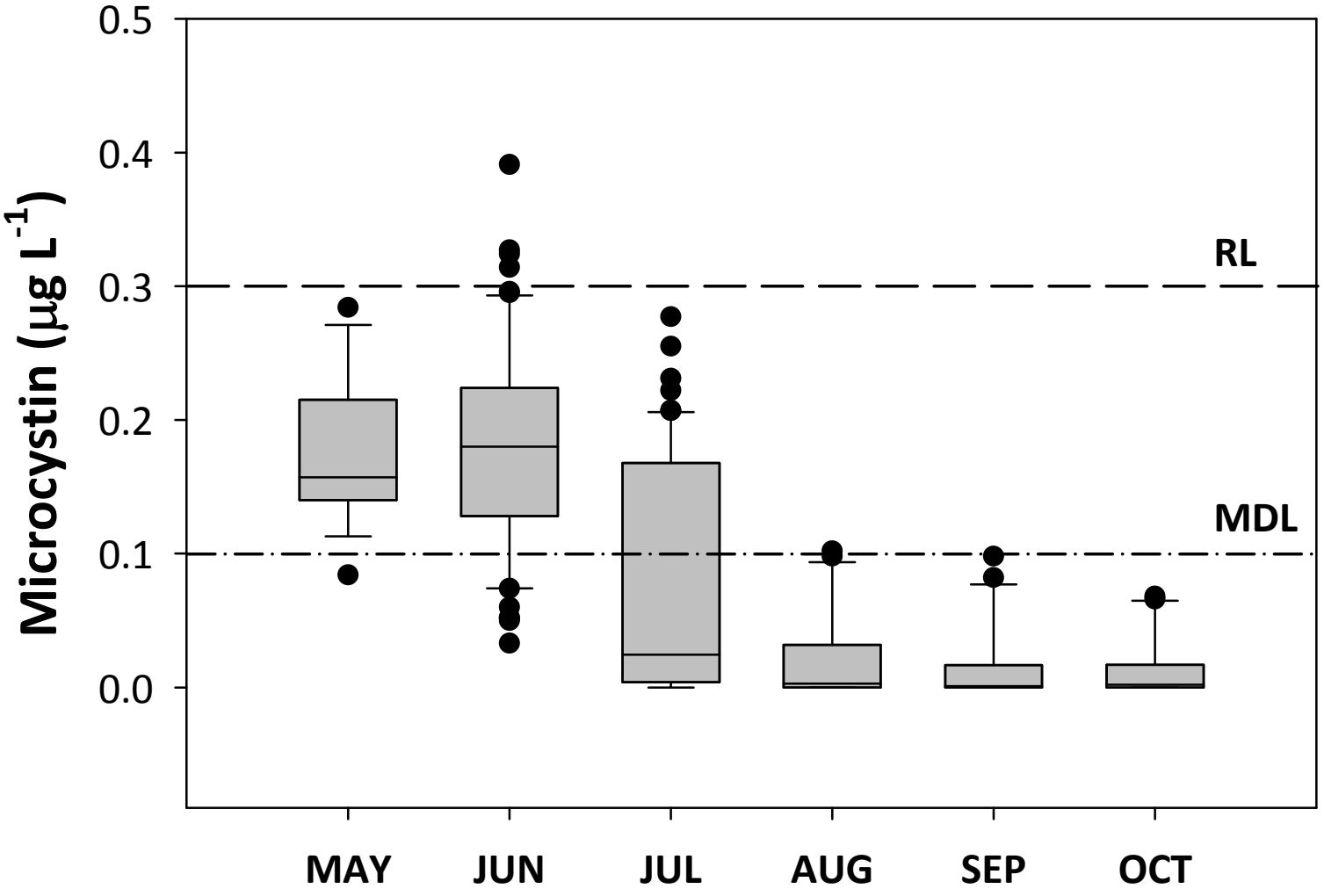
- Human Development Index (HDI)
  - Sum of agricultural and urban development
- Agriculture in the region:
  - Cattle grazing
  - Poultry
  - Pasture/grassland
- Urban development:
  - Northwest Arkansas is the fastest growing region in the state, and 14th nationwide.



- HDI ranged from 19% to 96%
- Nutrients increased in relation to human development across our study streams



Detecting Microcystin in the Water Column



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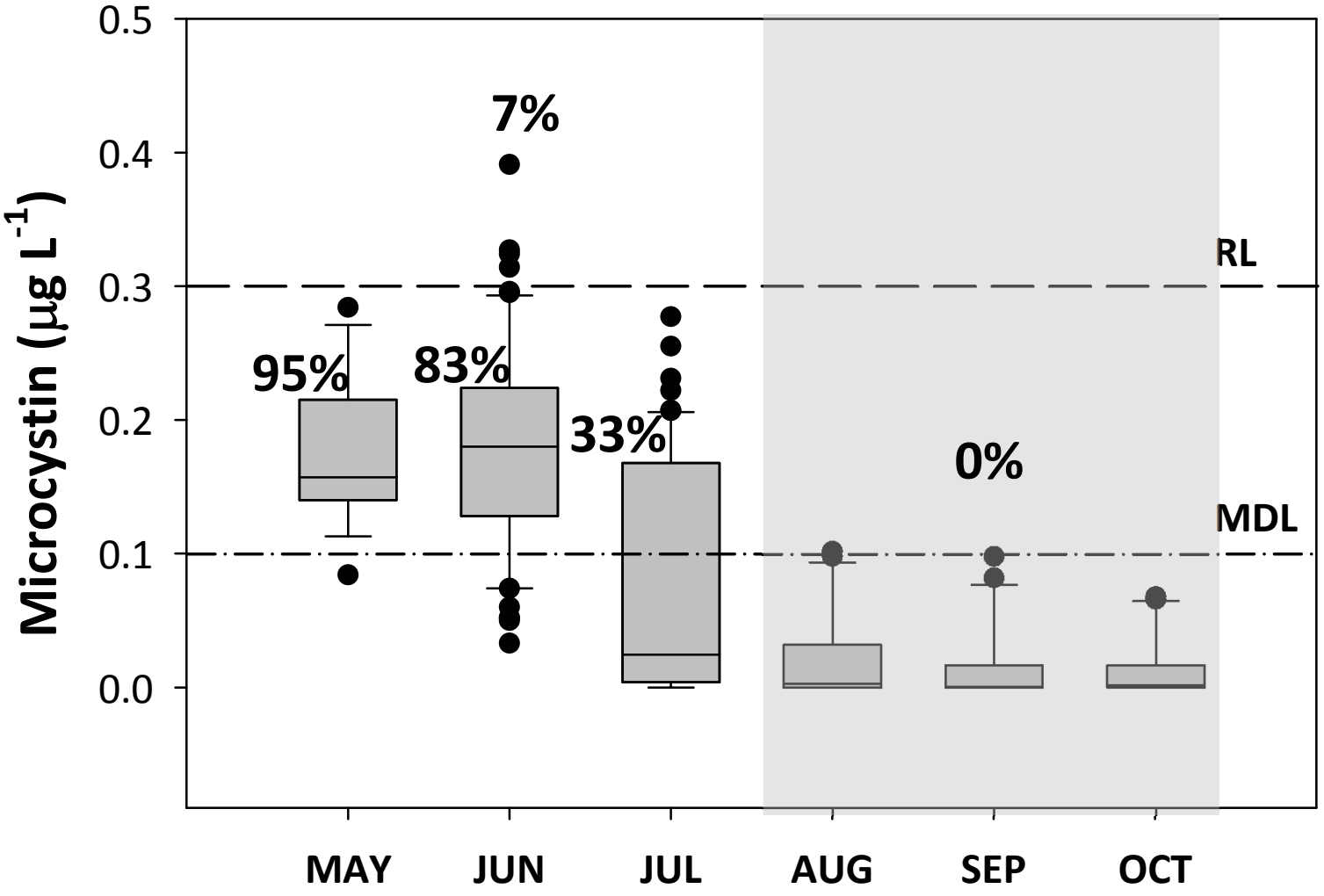
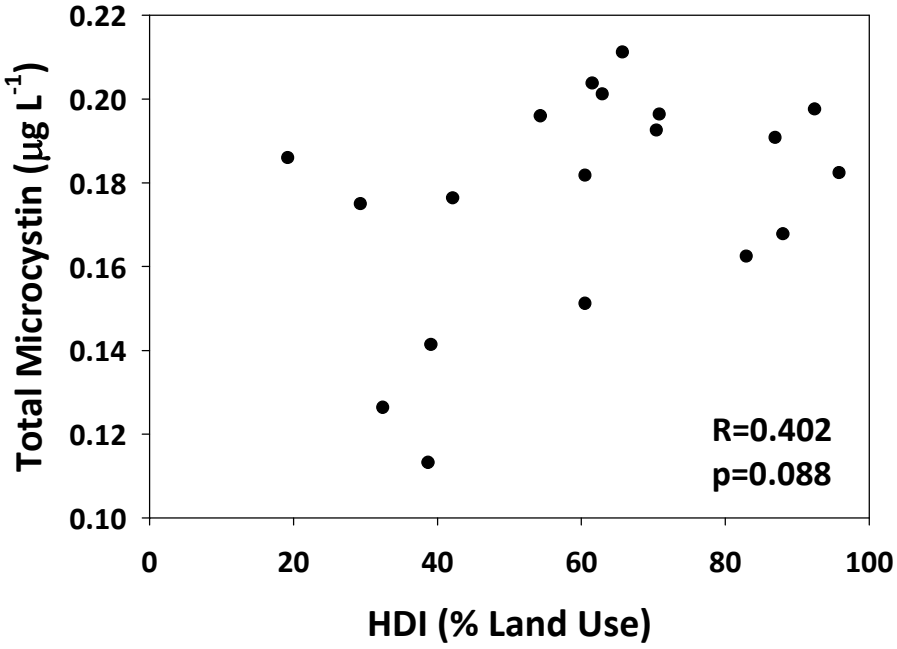


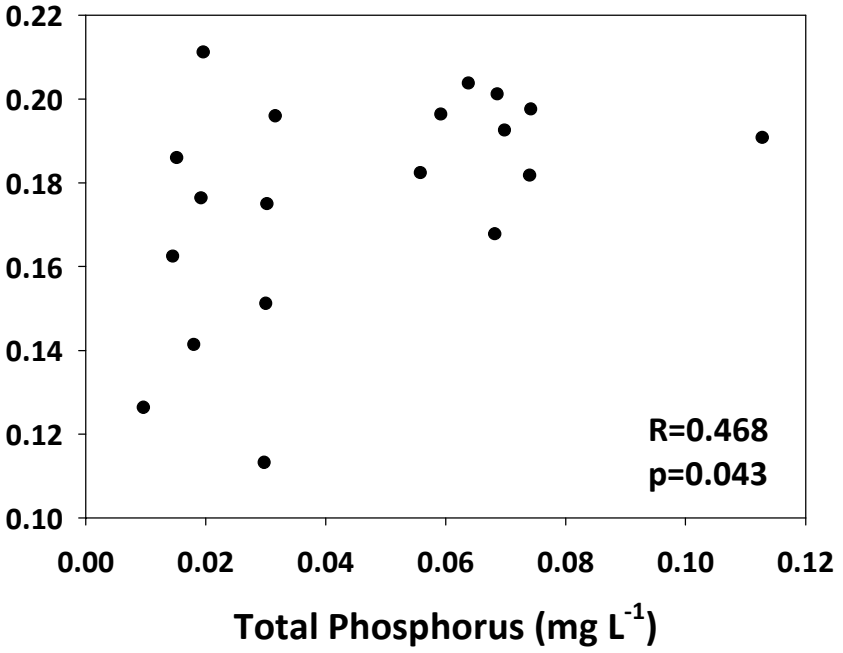
Detecting Microcystin in the Water Column

- Microcystin in the water column
  - Greatest in late spring/early summer
  - Mostly present in very low concentrations, below the reporting limit of the analysis (0.3 µg L^{-1})
  - Drops below the MDL (0.1 µg L^{-1}) after the first week of July.
- Site means from May 25th through July 2nd were used in the correlation analyses.

Water Column Microcystin

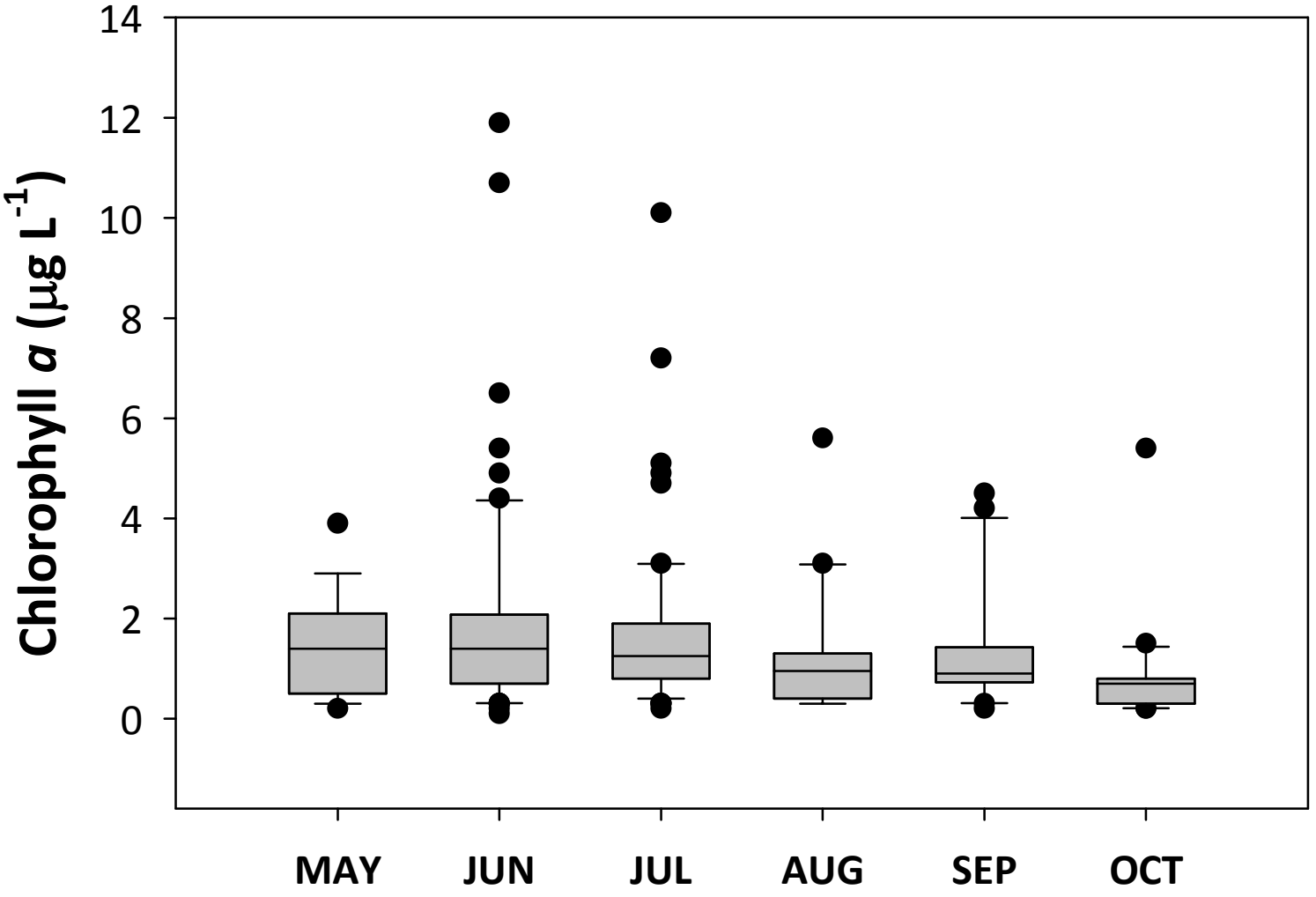
- Weak positive relationships with %HDI and TP.





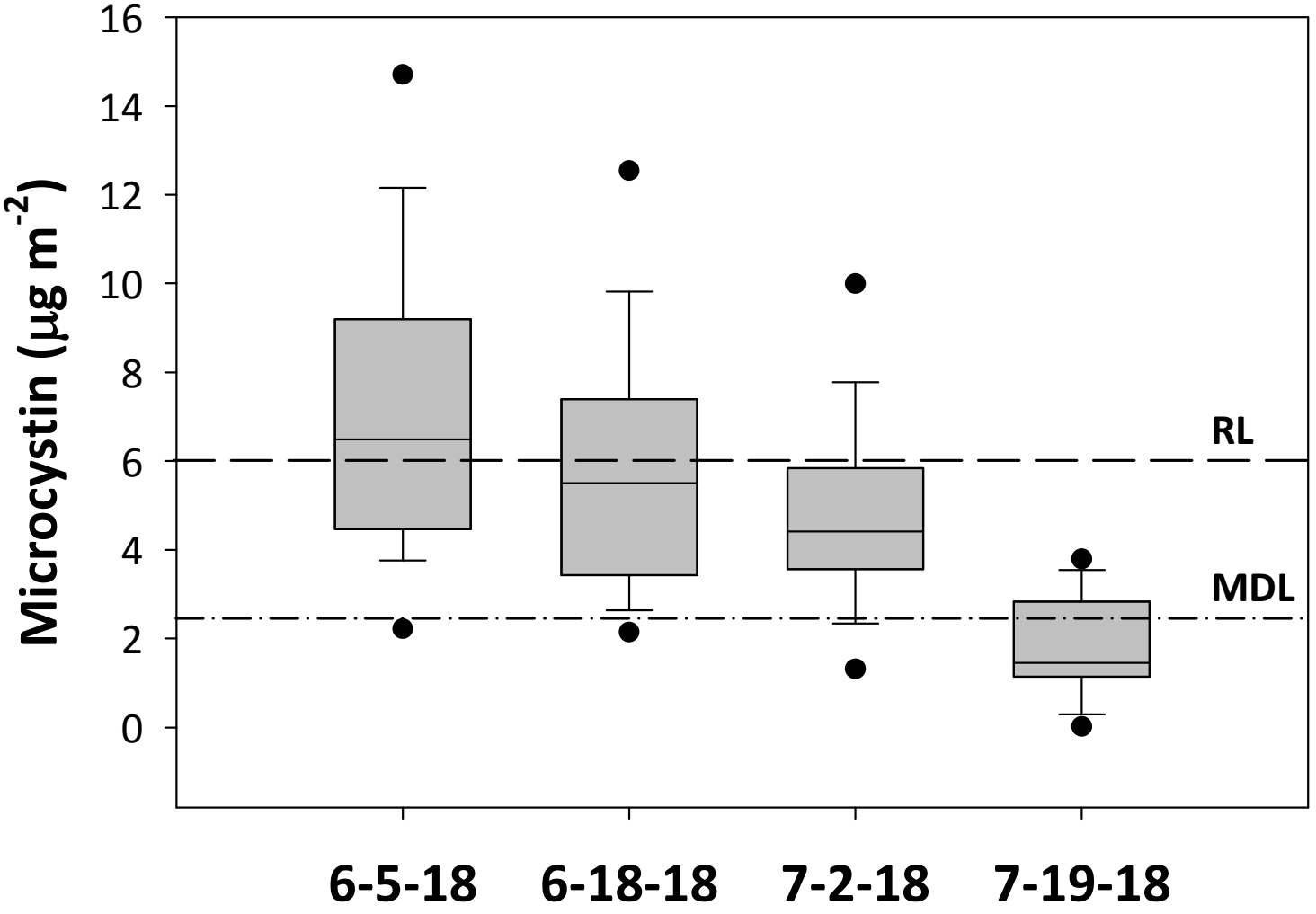
- Microcystin in the water column did not relate to phytoplankton CHL-*a*

Phytoplankton Biomass was Low



What about the periphyton?

Occurrence of Periphytic Microcystin



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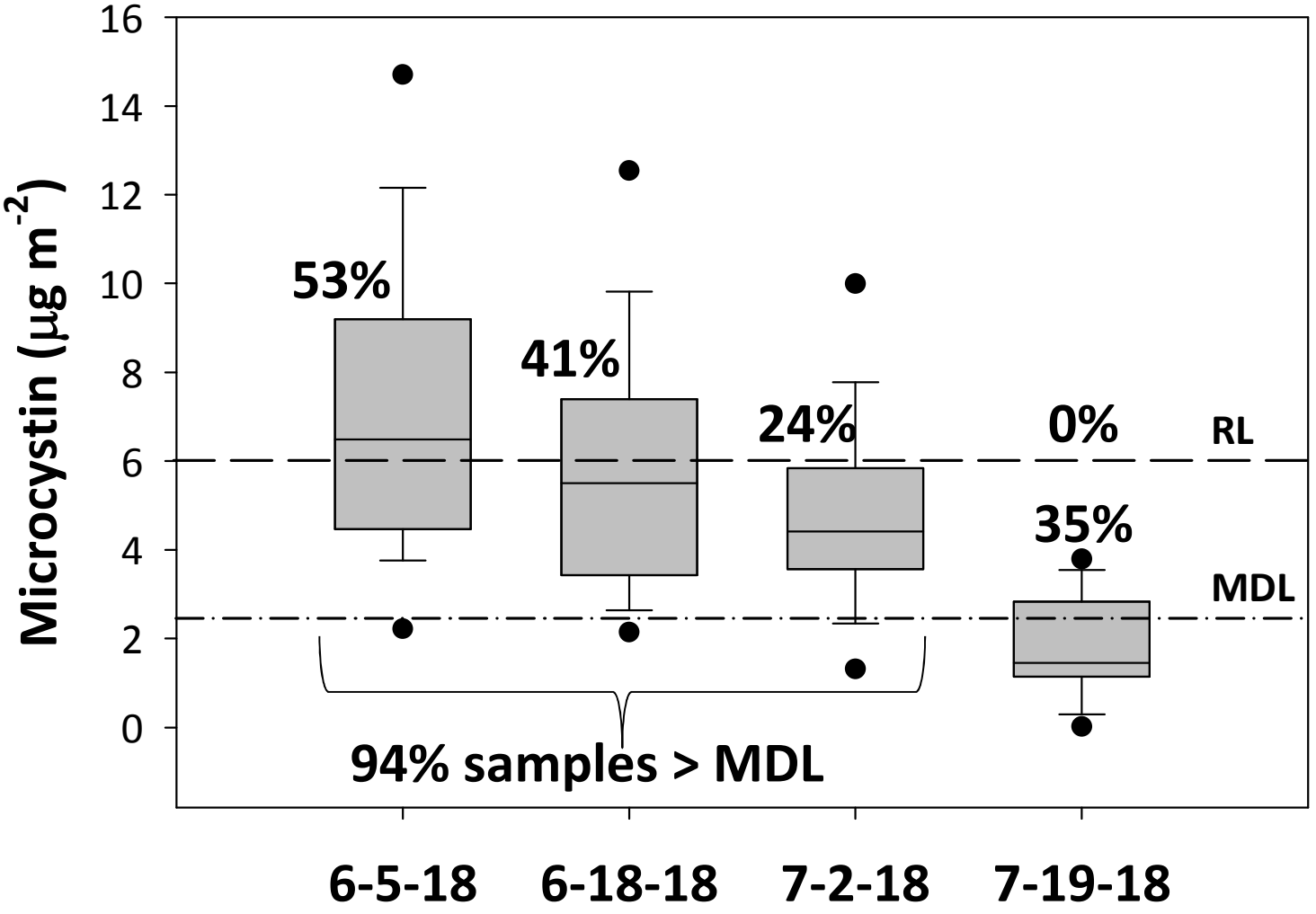
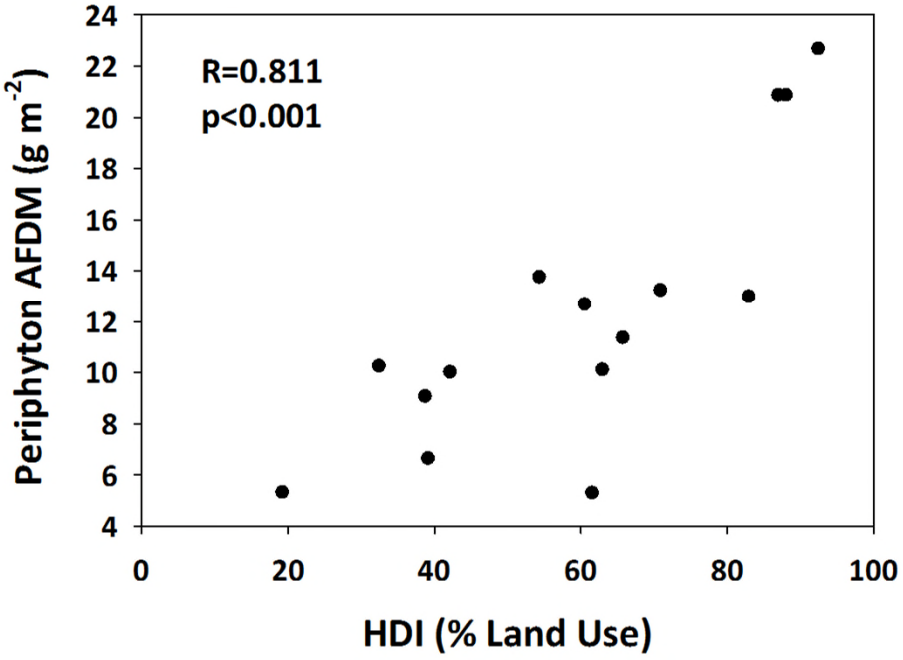


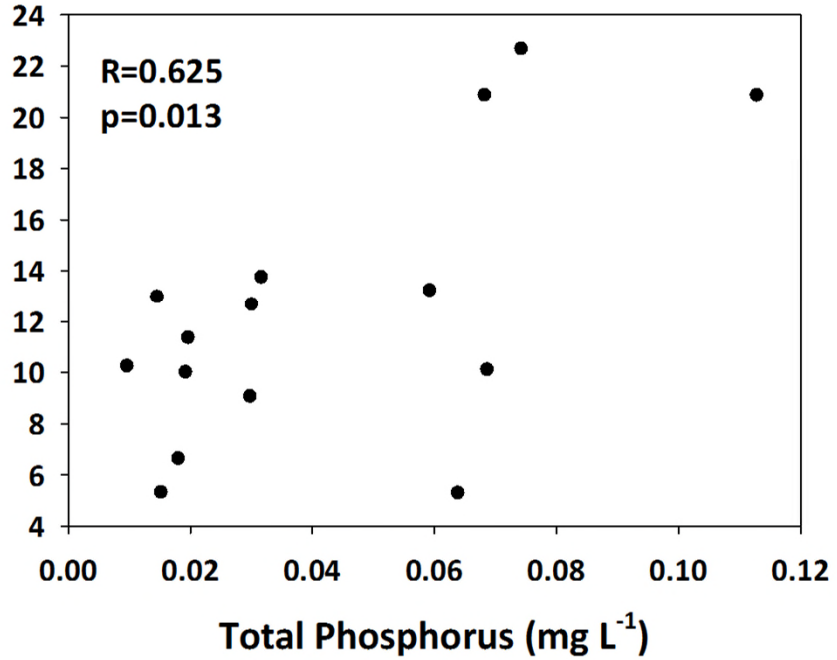
Occurrence of Periphytic Microcystin

- Microcystin content of the periphyton was greatest in early June and decreased through July.
- Site means from the first three sample periods were used in the correlation analyses.

Periphyton Relationships

- Periphyton biomass as AFDM related positively with % HDI and nutrients.





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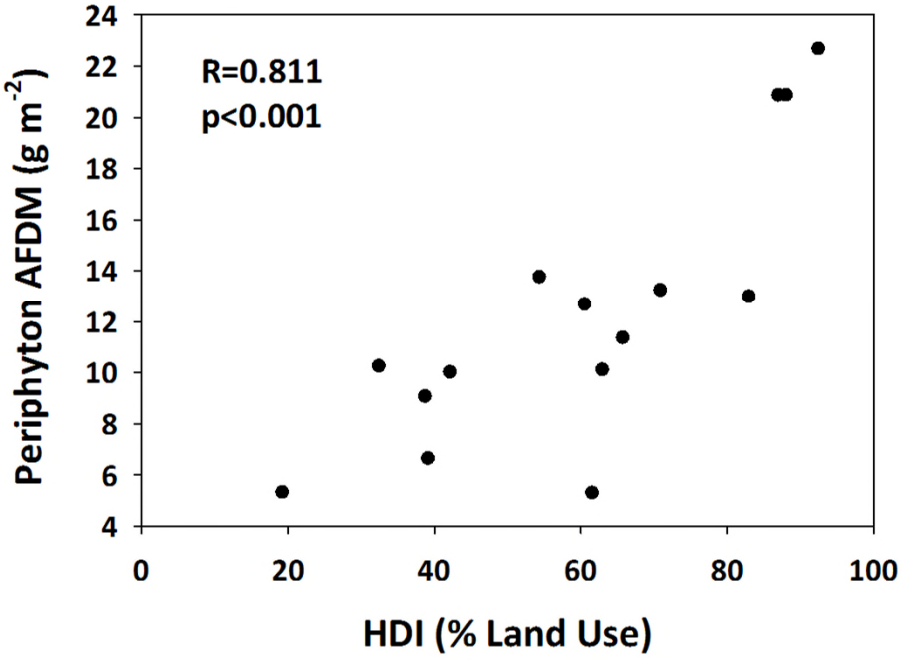
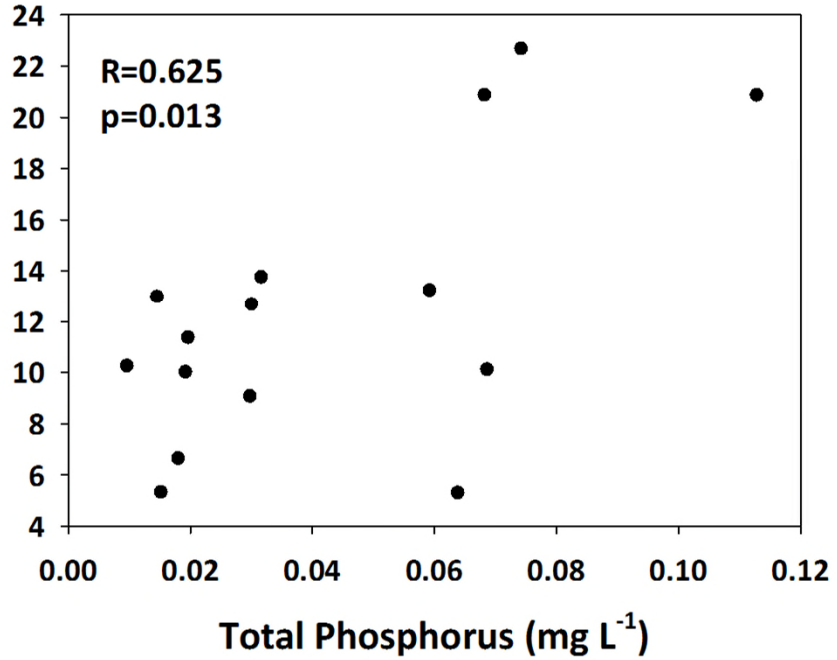
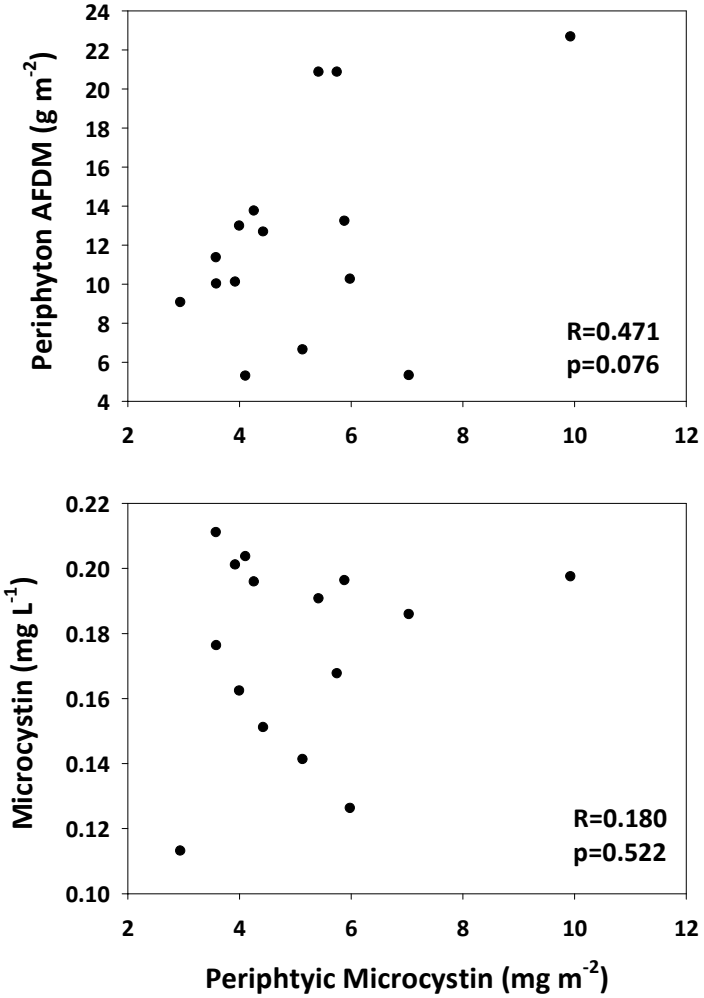




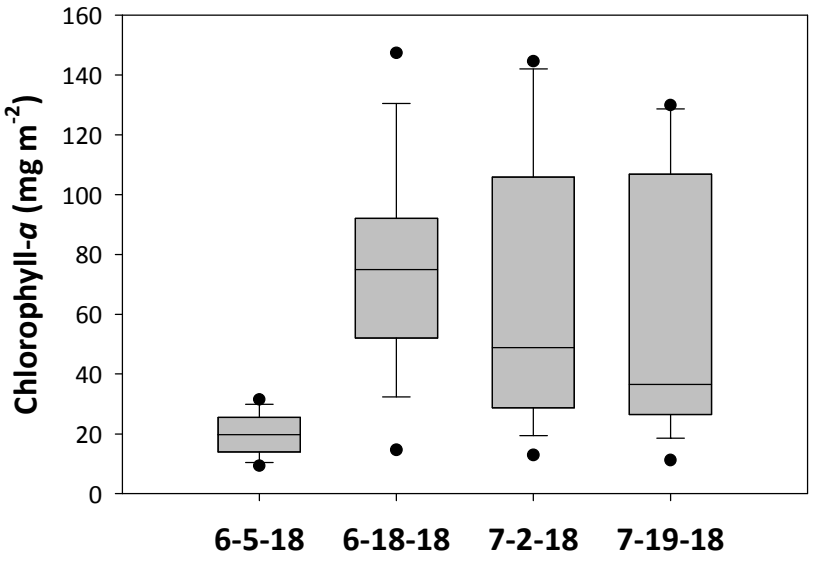
- Periphyton biomass as CHL-*a* had similar relationships.

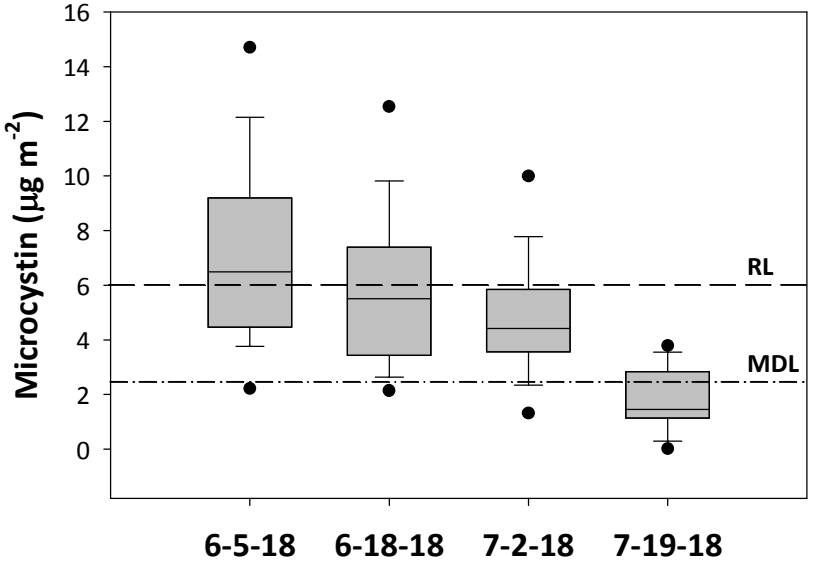
Periphytic Microcystin

- Periphytic microcystin had a weak correlation with AFDM, but not with CHL-*a*.
- Microcystin in the water column did not relate to periphytic microcystin



Periphyton biomass and microcystin content were inversely related across sample periods.





- This may suggest a shift in periphyton community composition through the summer.
- Microcystin in the water column also dropped below detection later in July.

Summary & Conclusions

- Microcystin does occur in NWA streams, but...
  - 99% of water samples and roughly half of periphyton samples analyzed were below the RL (0.3 µg L^{-1}, 6.0 µg m^{-2}).
  - Nearly half of the water samples were below the MDL (0.1 µg L^{-1}).
  - All water samples were well below:
    - EPA's drinking water standard (1.0 µg L^{-1})
    - WHO's recreation standard (10.0 µg L^{-1})
- Land use in the watershed and nutrients in the water column related directly to microcystin in the water column and indirectly to periphytic microcystin.

New Questions

- If the periphyton contributes microcystin and other cyanotoxins to the water column:
  - What controls the release of these cyanotoxins from periphyton mats?
  - From a monitoring stand point, what is the best way to account for this potential release of cyanotoxins?

Questions?

Acknowledgements:

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